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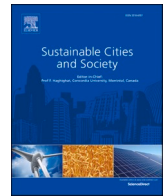
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Social innovation for a circular economy in social housing

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ABSTRACT

This study explored how social housing communities can contribute to the transition to a circular economy (CE) in cities. The CE promotes ways for rethinking and reshaping current practices of producing and consuming to enhance resource efficiency while satisfying our needs to enable us to prosper sustainably. Resource efficiency in cities relies on production and consumption patterns that are connected to people behaviours. Up to now, the CE has mainly concentrated on different levels of technological system innovations with limited attention to social practices and behavioural change. On the other side, communities and groups of interest show playing a crucial role in the promotion of sustainable practices through initiatives of social innovation (SI). Through case study analysis and comparison, the project investigated contemporary SI initiatives implemented by urban communities and groups of interest aiming at promoting alternative production-consumption practices. Seven types of SI for resource circularity have been identified. Based on this typology, the study defined potential opportunities, benefits and challenges for social housing communities. These findings also highlighted a complementary role that SI can play in the CE implementation in cities. Therefore, the project suggested the introduction of emerging SI concepts into the current CE approach to support development.

1. Introduction

The world's population living in cities is growing; in 2018, it was estimated 55.3 % of people lived in urban settlements, while by 2030, 60 % of them globally (at least 1.6 billion people) is expected to reside there (United Nations, 2018). Because of growing urbanisation combined with the current linear operating system of “take, make, and dispose of”, it is estimated that cities emit between 70 % of carbon emissions, consume over 78 % of the world's energy and 75 % of natural resources and, and produce over 50 % of global waste (United Nations Environment Programme, 2017). If current urban growth combined with low job availability and income trend because of city overcrowding and spatial mismatches (The World Bank Group, 2016), by 2025 one-third of citizens is expected to live in financial difficulties (McKinsey Global Institute, 2014). The CE offers clear potential to promote sustainable prosperity in our cities. A CE offers a framework to rethink and reshape current practices of producing and consuming to enable society, the economy and the environment to prosper in sustainable ways (EMF, 2017). Benefits from a CE implementation in cities consist of the increase of resource efficiency while reducing impacts on the environment and reinforcing the local economy (EMF, 2017). Until now the implementation of a CE has mainly been pursued at the technical level

through innovations in materials, products, business models and industrial systems with reduced attention to user practices and behaviours (Ceschin & Gaziulusoy, 2016). On the other side, resource efficiency in cities depends on consumption and production patterns that are linked to changes in people behaviour. Recent experiences on the implementation of a CE in social housing show the development of flexible and adaptable housing technological assets, while the contribution of social housing communities to the transition to a CE has not been considered yet. The literature on behavioural change highlights the crucial role played by communities and groups of interest in sustainable living as well as in the improvement of resource efficiency in cities (Dodman et al., 2017) by promoting alternative social practices. People are more willing to change and stabilize changed practices when they are engaged in collective initiatives with peers like neighbours (Jackson 2005). They are local wider initiatives that encourage alternative social practices or variations of established or mainstream routines (Haxeltine et al., 2016; Jaeger-Erben et al. 2015) through citizens' engagement in local communities and groups of interest's initiatives. These interventions are called social innovations. Even if it is acknowledged the complementary role of these bottom-up initiatives in combination with top-down initiatives in the implementation of a CE in cities, they are not well-known or well-established because they are mainly managed by

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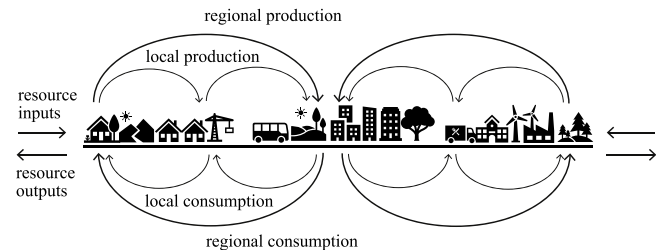


Fig. 1. Circular metabolism in cities (adapted from Clift et al. 2015; Currie & Musango, 2016).

locally based small groups of people and restricted by regulation, political and infrastructural obstacles (Prendeville et al., 2018).

This study aimed to understand the potential contribution of social housing communities in the transition to a CE in cities by exploring the phenomenon of SI for resource efficiency and circularity promoted by urban residential communities, groups of interest and citizens. After a general overview of the CE in cities and an exploration of the current implementation of a CE in social housing, the literature review focused on the role of communities, and groups of interest in the promotion of behavioural change for sustainable living through SI. The study gathered recent knowledge on SI and sustainability through a literature review. It then focused on understanding the phenomenon of SI for sustainable production-consumption in cities using case study analysis and comparison. This analysis provided an overview of contemporary SI initiatives implemented by urban communities and groups of interest among citizens for the promotion of alternative practices in cities. A process of comparison and grouping followed the analysis and allowed identifying seven types of SIs for a CE in urban communities, and groups of interest. Based on these results, the study defined the potential contribution of social housing communities to the transition to a CE in cities by specifying opportunities, benefits and challenges. These findings also highlighted the potential role that SI can play in the implementation of a CE in cities. Therefore, the project suggested the introduction of emerging SI concepts into a current CE approach to foster the development of SI opportunities for a CE.

2. Literature review

2.1. Circular economy in cities

The CE is an approach aiming to improve the management of resources in cities to enhance efficiency and thereby reduce resources demand, improve access to resources and support local economic growth, job creation and innovation (European Commission, 2015). This approach analyses resource flows within physical and social urban infrastructures to identify opportunities in which these infrastructures could be organized for using resources sustainably (United Nations Environment Programme, 2017). Urban metabolism assesses the efficiency of resources' flow in cities and allows identifying appropriate interventions to improve resource management and reduce waste generation (Musango et al., 2017). The urban metabolism can be defined as the “collection of complex socio-technical and socio-ecological processes by which flows of materials, energy, water, people, and information shape the city, serving the needs of its populace, and impact the surrounding hinterland” (Currie & Musango, 2016). The diagram below represents a circular metabolism city which connects resources, processes, and activities of providing housing, goods and services, and transporting people and good (Fig. 1).

A circular metabolism in cities consists of the efficient production and consumption of resource across processes and activities and closed loops of resource flows in which outputs become inputs (Clift et al. 2015). Resource inputs involved in the city's processes are materials, water, energy, information and people while outputs derived from city

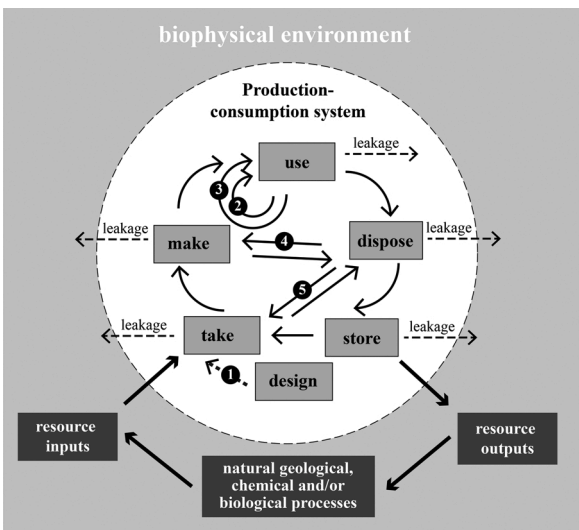


Fig. 2. Diagram for a circular economy (adaptated from Velenturf et al., 2019) (1. prevention by designing out all avoidable waste; 2. shared consumption; 3. reuse and repair; 4. remanufacturing; 5. recycling).

Table 1
ReSOLVE framework (Arup & EMF, 2018).

CE actions	business opportunities
regenerate	regenerate natural capital <ul style="list-style-type: none">• shift to renewable energy and materials• reclaim, retain and restore the health of the ecosystems and improve resilience (e.g., urban farming)• return recovered biological resources safely to the biosphere (e.g., composting)
	maximize assets utilization <ul style="list-style-type: none">• share assets by private or public sharing of products• reuse/second-hand use (e.g., reuse of structural steel)• prolong asset use periods by design for durability, maintenance, upgradeability, etc.
	optimize system performance <ul style="list-style-type: none">• increase the performance/efficiency of products• remove waste in production and supply chain• optimize the logistics system by the implementation of reverse logistics (e.g., industrial eco-park)• leverage big data, automation, remote sensing & steering (e.g., sensors for predictive maintenance)
loop	keep assets in closed loops and priorities inner loops <ul style="list-style-type: none">• refurbish products or components (e.g., building refurbishment)• remanufacture products or components• recycle materials (e.g., recyclable insulation with recycled content)• digest anaerobically (e.g., closed-loop zero-waste food production)• extract biochemicals from organic waste
	dematerialize resource use <ul style="list-style-type: none">• deliver virtual services directly (e.g., video conferencing, books, travel)• deliver virtual services indirectly (e.g., virtual offices, online shopping)
virtualize	select resources and technologies knowingly <ul style="list-style-type: none">• replace old with renewable materials (e.g., bio-products)• substitute traditional technologies with new ones (e.g., additive manufacturing, 3D printing)
exchange	<ul style="list-style-type: none">• substitute models focused on delivering products with models focused on services or product-service systems (e.g., façade leasing, multimodal transport)

dynamics include waste, emissions (to soil, water and air), people, information and income (Musango et al., 2017). Land is generally included among materials resources. People are also considered because of their role in terms of labour. Moreover, this component allows to include emergent urban activities like resource exchange that are missing in the traditional industrial ecology approach.

CE in cities promotes opportunities in four key urban systems:

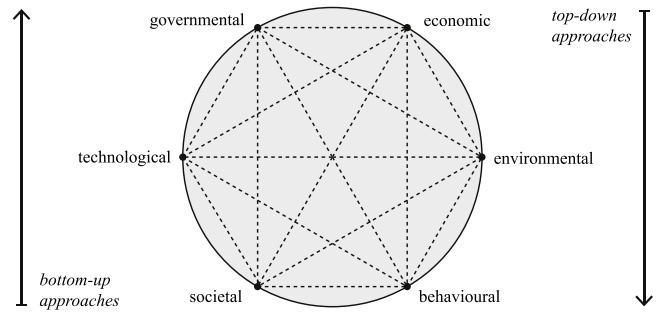
Table 2

CE strategies database (adapted from Kalmykova et al., 2018).

Stages (Velenturf et al., 2019)	Sub-stages and CE strategies (adapted from Kalmykova et al., 2018)
PRODUCTION	
1 Design	<i>Design</i>
Designing out all avoidable wastes	1 customisation/made to order 2 design for disassembly/design for recycling 3 design for modularity 4 eco-design 5 design for reduction
2 Take	<i>Material sourcing</i>
	6 diversity/cross-sector linkage 7 energy production/autonomy 8 life cycle assessment 9 material substitution 10 taxation 11 tax credits and subsidies
3 Make	<i>Manufacturing</i>
	12 energy efficiency 13 material productivity 14 reproducible & adaptable manufacturing
	<i>Distribution & Sales</i>
	15 optimised packaging design 16 redistribute & resell
CONSUMPTION	
4 Use	<i>Consumption/Use</i>
Sharing	17 community involvement
Reuse	18 eco-labelling
Repair	19 product as a service or product-service system/letting 20 product labelling 21 sharing 22 socially responsible consumption 23 stewardship 24 virtualise
	<i>Maintenance & reuse</i>
	25 maintenance & repair, upgrade 26 reuse, swapping
5 Dispose & store	<i>Collection</i>
Remanufacturing	27 extended producer responsibility 28 incentivised recycling 29 logistics/infrastructure 30 building separation 31 take-back and trade-in system
Recycling	<i>Refurbish/Remanufacture</i>
	32 refurbishment 33 remanufacture
	<i>Recycling/Recovery</i>
	34 by-products use 35 cascading materials 36 down-cycling 37 element/substance recovery 38 energy recovery 39 extraction of bio-chemicals 40 functional recycling 41 high-quality recycling 42 industrial symbiosis 43 restoration 44 up-cycling
	<i>Circular inputs</i>
	45 bio-based materials

buildings, mobility, products and food (EMF, 2017). In a production and consumption system that implements a circular economy approach, integrated resource flows circulate in closed-loop systems within social systems through the biophysical environment and the production-consumption system (EMF, 2015, Velenturf et al., 2019) (Fig. 2).

To support the implementation of a CE, the Ellen MacArthur Foundation designed the ReSOLVE Framework (EMF, 2015). This framework provides six actions - *regenerate*; *share*; *optimize*; *loop*; *virtualize*; and *exchange* - that businesses can apply to a production-consumption system at a strategic level to identify CE opportunities. Table 1 shows the

**Fig. 3.** Six pillars framework for a CE (Pomponi & Moncaster, 2017).

actions and potential business opportunities (Arup & EMF, 2018).

An overview of CE strategies to apply in each stage of a generic production-consumption system for implementing CE opportunities is shown in Table 2.

This framework is based on the database developed by Kalmykova et al. (2018) through the analysis of different CE theoretical approaches, strategies and cases. Strategies are arranged according to the phase that they implement. This database aimed at covering the lack of a comprehensive analysis of the available CE-enabling strategies and providing an implementation tool for developing new CE initiatives.

To analyse and cluster existing CE initiatives, a “six pillars” framework was developed in CE research on the built environment by Pomponi and Moncaster (2017). Through a critical literature review, they defined a framework composed of six fundamental dimensions for a CE: governmental, economic, environmental, behavioural, societal, and technological. Connections between pillars represent practical links between each pillar and the other dimensions that occur in the CE implementation. Bottom-up and top-down approaches are both included in the framework because of their mutual roles in the successful implementation of a CE (Fig. 3). This conceptual framework has proved to be a useful analytical tool in empirical research to guide the analysis and categorization of data to identify conceptual distinctions and organize ideas. It has been used as a starting point for researchers and practitioners to analyse existing CE initiatives (from grassroots innovations to governmental policies) and cluster them through the six pillars framework by classifying challenges for a CE as well as benefits derived from CE interventions (Pomponi & Moncaster, 2017).

Until now, the implementation of a CE has mainly focused on technological solutions at several levels from materials and products to business models and industrial systems. There has been less emphasis on changes in user behaviour and social practices (Ceschin and Gaziulusoy, 2016). However, resource efficiency is affected by consumption and production patterns linked to people behaviours (Dodman et al., 2017). Full implementation of a CE in cities follows the combination of changes in technologies and resource management infrastructures as well as changes in people’s production and consumption practices.

2.2. Circular economy in social housing

Social housing, as discussed here, is defined as a system in which households with limited financial resources are provided with housing for long-term below-market rent or price through a distribution system (Hansson & Lungren, 2019). The management of social housing can be distinguished between two main aspects: the management of the property and the management of people in the dwelling (Reeves, 2005). According to Forrest and Kearns (2001), residentially based networks are better able to build social cohesion thanks to everyday life, the experience of collaboration and a sense of belonging among members. Social cohesion implies building social relations, shared values and communities of interpretation, reducing disparities in wealth and income, and generally enabling people to build a sense of belonging into a common enterprise and the community facing shared challenges

Table 3
CE plan for Merton regeneration (KLH Sustainability & Clarion Housing, 2019).

principles	Building in layers	Waste hierarchy	Social value
strategies	Designing out waste	Demolition for maximum recovery value	Community-led design
	Developing standardisation strategy including off-site/modular components	Specifying high recycled content in products	Connecting with existing community re-use networks
	Ensuring buildings are easy to maintain and adapt	Supply chain integration	Developing a meanwhile strategy for under-utilised space
		Excellence in construction waste management	Promoting the sharing economy
			Supporting household and community recycling

(Berger-Schmitt, 2000). Therefore, residents in social housing are generally placed in a context that encourages the building of networks with the full potential of achieving social cohesion (United Nations, 2016). In social housing, the involvement of tenants in decisions about their housing and their neighbourhood has proven to be crucial to improve housing management services and service standards in general, generate more community ownership and co-create initiatives for improving their quality of life (like local employment opportunities, training and anti-social behaviour programs) (United Nations, 2016).

The implementation of a CE in social housing implicates not only the development of technological housing solutions for resource efficiency and waste reduction but also the promotion of production-consumption practices among residents that support resource efficiency and waste reduction. Recent experiences on the implementation of a CE in social housing in Denmark and the UK (GXN & Responsible Assets, 2018; KLH Sustainability & Clarion Housing, 2018) have mainly focused on developing flexible and adaptable housing technological assets by considering the intended lifespan of each building layers, optimizing building longevity and maximizing material reclamation at the end-of-life. The Circular Economy Plan for Merton Regeneration developed by KLH Sustainability & Clarion Housing (2018) (Table 3) have considered a set of activities (such as demolition for recovery, products with high recycled content, supply chain integration and construction waste management) which aims to eliminate and reduce waste before considering conventional management opportunities such as recycling. The plan focuses not only on the development of technological solutions for a CE, but it also includes the implementation of social value in the housing community as a critical element for a transition to a CE.

Through residents-led initiatives, the plan aims to reduce the waste generation in the community, while strengthening social network and cohesion, creating a sense of ownership for residents and encouraging a sharing economy (KLH Sustainability & Clarion Housing, 2018). While this plan shows an emerging interest among Housing Associations to engage their housing communities in the transition to a CE, this topic has not been yet explored in research to support them.

2.3. Behavioural change within urban communities

The literature acknowledges that technological innovation and supply-side innovation are not enough to achieve sustainable development since they cannot fully affect unsustainable resource use (Jackson, 2009). Moreover, sustainable development requires people's involvement and approval as well as changes in citizens' values, attitudes and practices (Dolan et al. 2010), and these relate to the problem of

promoting behavioural changes for sustainable living. In the context of CE, behavioural change refers to actions for promoting changes in citizens' production and consumption practices and choices (Clift et al., 2015). Choices and behaviours are strongly affected by the social dimensions of everyday life, social norms and social context. Because of cities' dynamic development and pressures, they hold an important role in enabling appropriate environments for the emerging of initiatives and collective actions to promote behavioural changes. (Clift et al., 2015). There are two complementary theoretical approaches to behavioural change for sustainable living that provide a perspective of how people live and how they can be influenced to pursue sustainable living practices (Whitmarsh et al., 2011). One asserts that individual practices are generated and constrained by large scale infrastructure and social systems. This approach shows system features (technologies, standards, laws, conventions, infrastructures) and constraints affecting individual choices and everyday life practices (Shove and Spurling, 2013). The other states that even if the behaviour is framed by social context and available norms as well as constrained by habits and practices, changes of individual behaviours and values are significantly affected by events, interactions and incentives that enable reciprocal influence among people in a group (Jackson 2005). The literature shows that people are more willing to change and stabilize changed practices when they are engaged in collective initiatives with their peers like neighbours. These two complementary approaches provide a view of the city as a complex metabolic system and as a combination of upstream and downstream interventions managed by a decision-making community to collaboratively change ways of living (Jackson 2005). Accordingly, the promotion of behavioural changes for resource efficiency requires a combination of actions in which "upstream" measures (urban infrastructures, regulations, standards and incentives) for dealing with structural constraints are integrated with "downstream" measures (local and individual/community-focused actions and incentives) for facilitating and encouraging sustainable lifestyle and practices in communities of place and interest (Clift et al., 2015). Similarly, it is acknowledged that the CE in cities can be fully implemented only if institution-driven initiatives (also called top-down) are combined with society-driven actions (also called bottom-up). Top-down initiatives are interventions promoted by institutions (like municipal/local government) while bottom-up initiatives are interventions promoted by NGOs, communities, networks, businesses and citizens (Prendeville et al., 2018). Despite the complementary roles of top-down and bottom-up interventions, bottom-up initiatives are rarely investigated. They are harder to identify because they are mainly managed by small locally based groups of people, and are limited by regulatory, political and infrastructural constraints (Prendeville et al., 2018). Examples include recycling social enterprises, organic gardening cooperatives, community composting plans, urban farmers and markets, low-carbon cohousing developments renewable energy cooperatives and car-sharing schemes. Since they encourage changes in production and consumption practices through citizens' engagement in local communities and groups of interest, this study focused on this category of interventions called social innovations (SIs).

2.4. Social innovation and sustainability

SIs are "changes in social practices and relations involving new ways of doing, organizing, knowing and framing" (Avelino et al., 2019; Haxeltine et al., 2016). The main characteristic is the "fact that people do things differently due to this innovation, alone or together. What changes with SI is a social practice; in other words, the way how people decide, act and behave, alone or together" (Franz et al., 2012). SIs consists of new products and services, processes, markets, collaborative platforms, organization forms (social movements or institutions), and business models (The Young Foundation, 2012). They are context-specific initiatives implemented locally but connected to networks globally (Avelino et al., 2019). SIs do not relate to any specific

sector of the economy. They can take place in all four sectors: 1) non-profit sector; 2) public sector; 3) private sector (social enterprises and businesses), and 4) informal sector (informal networks, associations and social movements). An SI initiative can involve more than one sector; it can start in one sector and then scale up in others, or it can engage a multiplicity of actors across sectors (The Young Foundation, 2012).

SI is generally focused on changing a social phenomenon (social practices or relations) and not necessarily oriented to address social goals (Avelino et al., 2019). The aim of changing a social practice is essential as the process of enhancing people's capacity to act by engaging them in the development and sustaining of the innovation. People are involved through the creation of new roles and relationships, development of new assets and capabilities and improved access to power and use of resources (The Young Foundation, 2012). As a result, they are empowered (Simon et al., 2014). Engagement and empowerment constitute requirements for facilitating the implementation of SI, but it is also a separate, significant aspiration (Avelino et al., 2019). Citizen engagement has a decisive role in the SI implementation to understand complex needs, collect ideas for new and better solutions and address complex challenges. It refers to how citizens are involved voluntarily in developing and sustaining new solutions to societal and environmental challenges (Davies and Simon, 2013). Citizens are engaged voluntarily in activities usually directed towards collective actions aiming at common goals by 1) sharing information and resources, 2) identifying problems, underlying issues and solving them collectively, and 3) taking collective decisions which influence community policymaking and government (Davies & Simon, 2013). Empowerment refers to the intrinsic citizens' motivation that stimulates their engagement in an activity. It is based on the measure to which they have a sense of choice ('I can determine what I do'), a sense of competence ('I am good at what I do'), a sense of meaning ('I care about what I do'), and a sense of impact ('I can make a difference') (Thomas & Velhouse, 1990). Through this experience, stakeholders may be empowered: they may enjoy increased autonomy (by the experience of choice and competence), power and influence capacity (Thomas & Velhouse, 1990).

The literature on sustainable development recognizes SI as a force for promoting sustainable social practices because it can align individual interests with social and environmental benefits and promote mutually beneficial solutions towards sustainability (Science Communication Unit, University of the West of England, Bristol, 2014). SI has been acknowledged as a crucial aspect for the improvement of resource efficiency in cities by the promotion of behaviour changes in production and consumption practices (Dodman et al., 2017). Through SI, citizens with reduced available resources (food, energy, water, and fabricated products) can develop innovative opportunities to satisfy their needs efficiently, achieve social and environmental goals and benefit from new capabilities, improved autonomy and self-reliance (Dodman et al., 2017; Manzini, 2015).

The literature categorises the main practices of a generic production-consumption system into production and consumption, and an additional practice called "prosumption" which involves production and consumption together (Ritzer & Jungerson, 2010). Prosumers are defined as "individuals who consume and produce value, either for self-consumption or consumption by others, and can receive implicit or explicit incentives from organizations involved in the exchange" (Lang et al., 2020). For example, prosumers produce products for their consumption or produce energy for their energy needs or contribution to the local distribution network. They generally employ production facilities in which a large number of people work cooperatively (called commons-based peer production) such as FabLab. Based on knowledge on the transformation of social practices and routines, Jaeger-Erben et al. (2015) developed a framework to recognize and categorize changes in social practices. This framework was developed by combining two different types of focus that generally influence a process of innovation in social practice: 1) the problematization of established

Table 4

Alternative consumption practices – framework and modes (Jaeger-Erben et al. 2015).

Orientations in the formulation of alternative practices	Problematization of established practices	
	emphasis on problematic meanings inherent to the social practices or the whole practice field	emphasis on the lack of possibilities of consumption in terms of services, infrastructures, products
focus on alternative social settings	Community-empowering consumption Strategic consumption	Commonly organized consumption
focus on individual competences	Competence-expanding consumption	
focus on alternative material arrangements	Resource-light and waste-avoiding consumption	Need and utility-oriented consumption

Table 5

Definition of alternative consumption modes (Jaeger-Erben et al. 2015).

Types of SI	Definition
Community-empowering consumption	it is characterised by community building as a value and a way to consume differently (e.g. urban gardening)
Strategic consumption	it is focused on citizens participation in short-term joint actions promoted by third parties for strategic consumption or on their integration as "prosumers" in the development of a product, services, or product-service systems (e.g. campaigns for energy saving, like Energy Neighbourhoods or in Carrot Mobs)
Commonly organized consumption	it is based on consumption communities that share and exchange products and services. Commonly organized consumption practices are encouraged through new social settings (such as social media and the internet) provided by suppliers, non-profit organizations, or consumer networks (e.g. product sharing)
Competence-expanding consumption	it focuses on providing facilities for prosumption and repairing as well as for facilitating competence acquisition and engagement by material settings like workshops and by social settings like platforms for knowledge exchange (e.g. repair café)
Resource-light and waste-avoiding consumption	it focuses on redefining waste as a resource and promoting its turning into products by providing alternative provision systems (e.g. upcycling)
Need and utility-oriented consumption	it focuses on satisfying needs by providing products as services to avoid inefficiency (e.g. renting)

practices and 2) the formulation of alternative practices. In the first phase of the process, practices are problematized by considering expectations, needs and attitudes on one side and available opportunities on the other side. Then in the following phase, alternative practices are formulated based on the three facilitation elements (Jaeger-Erben et al. 2015; Shove et al., 2012): 1) motivation and affective aspects linked to social meanings, values, and norms; 2) individual competences; and 3) material arrangements (services, infrastructures, products). Jaeger-Erben et al.'s framework was applied to sustainable consumption (Table 4) and contributed to identifying five modes of alternative practices described in Table 5.

The process of social practice innovation follows three stages: 1) challenge of established social practices; 2) development of alternative practice; 3) stabilization of social practice, and then replication (Jaeger-Erben et al. 2015). Key barriers commonly observed across SI initiatives to the development of the field are both external such as the scarcity of finance mechanisms, the absence of networks and intermediaries, the reduces availability and access to information, as well as internal such as the lack of quantitative evidence on the impact and the shortage of appropriate capacity and skills (TEPSIE, 2014).

Table 6
Methodological approach.

Activity	Outcome
1 Case analysis	Analysis of 56 case studies of potential SI for a CE in urban communities and groups of interest
2 Case comparison	Categorization and characterization of SI types for a CE in urban communities and groups of interest
3 Discussion	Definition of social housing communities' potential contribution to the transition to a CE in cities Knowledge contribution to the CE approach by the development and inclusion of theoretical insights on SI for a CE

Table 7
Theory-based template.

Content name	
resources inputs and outputs	land, materials, energy, water, information, waste, people/labour, local income
urban system involved	built environment system, mobility system, product system, food system
activities/offers	product-service, process, market, platform, organization form
initiators/promoters	
sector	non-profit, public, private, informal
target groups	citizens 'groups of interest and urban communities
place (city, country)	mainly in industrialized countries (Europe, US), a few in newly industrialized countries (one in India, one in Indonesia)
date of development	1990 s–2010 s (4 stabilized/replicated initiatives in the 1970s)
Innovation process	
problem definition	environmental, technological economic, social, governmental, behavioural
challenging of established practices:	production/presumption/consumption because of meaning and values or material arrangements
alternatives developed (changes in established practices)	production-consumption practices for a CE (see Table 2)
CE actions implemented	regenerate, share, optimize, loop, virtualize, exchange
engagement and empowerment strategy adopted	provide information & resources, solve problems, take and influence decisions
current status of developed alternatives	stabilized, diffused/replicated, completed/ended
obstacles, challenges, failures and factors for success	internal and external factors
Outcomes	
assessment of impacts/effects (based on potentials and empirical evidence)	environmental, technological economic, social, governmental, behavioural

3. Methodology

This section describes the methodological approach adopted and the qualitative case studies analysis and comparisons applied.

3.1. Methodological approach

The methodological approach combines deductive and inductive strategies. This approach is based on an “adapted version of Grounded Theory approach” (Perry and Jensen, 2001) in which data analysis is performed according to dimensions or categories obtained from theory and then integrated and further implemented inductively through empirical data. A theory-based template was designed based on theory to analyse the selection of SI cases. It has been described in detail below. Another element was the categorization of SIs based on the application of the framework developed by Jaeger-Erben et al. (2015) on social practices innovation combined with information collected by the template. In this study, Jaeger-Erben et al.'s framework was adopted to identify alternative production-consumption practices and accordingly,

the classification of the selected case studies. It resulted in the characterization of seven types of SI for sustainable production-consumption practices in urban communities and groups of interest, the identification of the potential contribution for social housing communities to the transition to a CE in cities, and the formulation of theoretical insights for knowledge contribution to the current CE approach. Table 6 shows the approach in terms of activities and outcomes.

3.2. Case study analysis and comparison

The empirical basis of the study consists of the analysis of case studies and comparison. In the case study analysis, Google's Internet search engine was used to identify case studies, based on the combination of the following keywords: ‘social innovation’; ‘circular economy’; ‘sustainable practices’; ‘circular practices’; ‘sustainable production’; ‘sustainable consumption’ and ‘prosumption’. For this study, over 100 research articles, research project outputs, policy reports, websites of initiatives were scrutinized to find cases of SI implementing CE practices in urban communities and groups of interest. The case studies were chosen from SI initiatives identified based on established criteria. The criteria for selection were: 1) urban system involved (building, mobility, product and food systems); 2) target groups: citizens' group of interest and urban communities; 3) place: industrialized countries and newly industrialized countries; 4) date of development: 1990 s–2010 s (earlier initiatives were included when they are still active, stabilized and replicated) 5) challenging of established practices (production, consumption or prosumption) and development of alternative production and consumption practices based on the strategies for a CE reported in Table 2; 6) status of the initiative (stabilized, diffused or completed while under-development initiatives were excluded). We detected 56 cases of SI initiatives for a CE in urban communities and groups of interest. They were analyzed by collecting data based on a theory-based template shown in Table 7. It includes general information of each case, an analysis of the innovation process implemented, and the impact assessment founded on potentials and empirical evidence. The template was developed according to knowledge gathered in the preliminary literature review and validated by the Jaeger-Erben et al. (2015) study.

Data were gathered for each case study, and information was summarized in a cross-case matrix form presented in Appendix A to support comparison. The cross-case matrix form consists of the three distinct domains and sets of criteria reported in the Theory-based template. Specifically, it includes: in the “content” domain, 1) managed resource inputs/outputs based on the definition on urban metabolism asserted by , 2) involved urban system based on the key urban systems for a CE (EMF, 2017), 3) activity/offer according to SI classification developed by The Young Foundation (2012), 4) SI organization type according to The Young Foundation (2012); in the “innovation process” domain, 5) initial problem definition based on the “six pillars” framework (Pomponi & Moncaster, 2017), 6) challenge of established practices according to the Jaeger-Erben et al. (2015)'s framework on social practice innovation, 7) implemented CE actions according to the ReSOLVE framework (Arup & EMF, 2018), 8) citizen engagement type according to Davies & Simon (2013), 9) current state of the innovation process according to Jaeger-Erben et al., 2015, and 10) obstacles according to TEPSI, 2014; in the “outcome” domain, 11) impact areas based on the “six pillars” framework (Pomponi & Moncaster, 2017). Information for the analysis was collected from a variety of documents provided by websites, scientific publications and social media publications. Due to time restrictions and current access limitations, we depended on traditional data source collection and processing. Advanced techniques such as geo-big data analysis and advanced machine learning techniques were not included in the study, but their inclusion in future can be beneficial.

The process of comparison and grouping of case studies was performed by a qualitative cross-case comparative analysis (Miles et al., 2013; Yin, 2003) to identify modes of alternative social practices, then types as well as patterns, clusters, similarities and disparities across

Table 8
Alternative production-consumption practices – framework and modes (adapted from Jaeger-Erben et al. 2015).

Orientations in the formulation of alternative practices	Problematisation of established practices					
	production		prosumption		consumption	
	(1)	(2)	(1)	(2)	(1)	(2)
focus on alternative social settings			Community-empowering		Community-empowering	Commonly organized
focus on individual competences	Knowledge-expanding		Strategic		Competence-expanding	
focus on alternative material arrangements	Resource-light/waste-avoiding		Competence-expanding		Resource-light/waste-avoiding	Need/utility-oriented

(1) Emphasis on problematic meanings inherent to the social practices or whole practice field - values, needs and attitudes.
(2) Emphasis on the lack of possibilities of intervention - services, infrastructures, products).

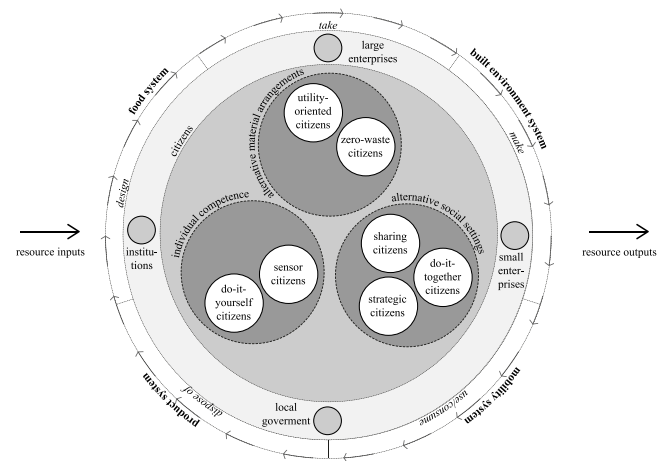


Fig. 4. Types of SI for resource circularity in urban communities and groups of interest.

types. The categorization was developed by the framework shown in Table 8, based on Jaeger-Erben et al.'s framework (2015) adapted considering established practices in a generic production-consumption system. This activity identified modes of alternative production, prosumption and consumption practices for a CE across the case studies. Based on this, we identified and characterized seven types of SI for a CE in urban communities and groups of interest.

4. Results

This section provides the results derived from the case analysis and comparison. Identified initiatives have been analysed according to selected criteria. Collected data have been reported in a table for comparison (Appendix A). Through empirical observation and comparison of the sampling, the analysed initiatives have been categorized into three main categories and distinguished into seven main modes of alternative production-consumption practices:

- 1) initiatives focused on alternative social settings and distinguished into a) *community-empowering prosumption and consumption* (13 cases), b) *strategic prosumption* (4 cases) and c) *commonly organized consumption* (10 cases);
- 2) initiatives focused on individual competences and distinguished into a) *competence-expanding prosumption and consumption* (6 cases) and b) *knowledge-expanding production* (4 cases);
- 3) initiatives focused on alternative materials arrangements and distinguished into a) *resource-light and waste-avoiding production and consumption* (15 cases) and b) *need/utility-oriented consumption* (4 cases).

Based on identified modes, seven types of SI for CE practices in urban communities and groups of interest have been defined (Fig. 4). A description of each mode and related type is reported below.

4.1. Community-empowering prosumption and consumption

This mode is mainly implemented through SI initiatives promoted and managed by communities of place or interest. They consist of citizens who share concerns about prosumption and consumption practices and their effects on the environment, economy and society. They hold common meaning and values on more sustainable resources management in their lives involving various urban systems (see, for example, Transition Towns, Ecovillages, and Eco-Self-Build Communities). Transition Network is a global network of communities aiming at building 'local resilience' for dealing with current challenges by claiming back the economy, triggering entrepreneurship, rethinking work, promoting skills and building connections through community energy, local currencies, and food projects (Longhurst, 2015). Some initiatives promote alternative practices in specific resources management such as the self-production of energy by Community Energy, food waste management by Community Composting, local food production by Community Growing or land reclaiming by Community Gardening. Community energy initiatives are citizen-driven energy projects in which citizens participate in the energy prosumption (Hewitt et al. 2019). Community gardening initiatives like Stadstacker in Munich maintain gardens in which there are no individual plots, but they are entirely managed by gardening groups (Buić et al., 2017). Initiatives are mainly implemented in the built environment and food systems while a few of them such as the intentional communities (see Ecovillages) operate across multiple systems. Eco-villages are community-led living laboratories developed by participatory processes to promote low-impact and high-quality lifestyles (Haxeltine et al., 2013). Initiatives of this type are promoted by informal groups or no-profit organizations aiming at developing solutions for sustainable resources management or living, increasing awareness through discussion and sharing information, resources and skills. This type of initiatives is well-established: most of the initiatives are diffused and replicated showing impacts on sustainability in the environmental, social, economic and behavioural areas. Moreover, we observed that initiatives generally progress by developing networks for replication. For example, the Global Ecovillage Network (GEN) is an international network of around 500 eco-villages and regenerative communities. Thanks to the new skills learnt through the innovation process, a few of them have been also able to develop enterprises to support replication. For example, members of the Ashley Vale eco-self-build community have launched their businesses (Bright Futures) after the implementation of the SI initiative. Ashley Vale eco-self-build community is a community group in the UK developed through the redevelopment of a brown-field site in a sustainable housing development composed of affordable self-built and self-finished houses, a community space and three work units (Broer & Titheridge, 2010).

Common obstacles observed in this type of initiatives are both, internal and external: the need for skills and training, the necessity for professional coordination and sustainable business models, the lack of infrastructure support (from governments) and financial support (most of the work is on a voluntary base). This SI type was called *do-it-together citizens*.

4.2. Strategic prosumption

This type focuses on informal initiatives promoted by third parties in which citizens are involved in building short-term groups and performing temporary co-creation actions (see, for example, Ugly Indians, and Park(ing) Day). They are against the lack of advocacy for access to public land and reclaim urban space mainly used for parking or perceived to be neglected or misused. These communities are built locally for short periods based on shared concerns and values about the built environment system. Participants address not only environmental and social challenges but also governmental shortcomings. For example, the Park(ing) Day annual event encourages citizens to reclaim space for rest, relax and play and react to the dominance of cars in cities. These initiatives promote alternative ways of producing and using resources like the land by participatory planning and co-production. In temporary actions, networking represents one of the key elements for the implementation of this type of interventions. This category also includes participatory action projects such as 596 Acres. It is a project developed by citizens to create an interactive map on vacant urban spaces aiming at promoting campaigns led by citizens to turn urban land into community spaces (such as gardens, farms, and playgrounds) as well as foster social cohesion and contribute to productive land use. These specific initiatives start from the interests of participants that are engaged in responding to a common issue relevant to the community and working with a facilitator to develop solutions collaboratively, promote common knowledge and increase awareness (Cooper et al., 2007). In the analysed initiatives, adopted actions for a CE are mainly focused on regenerating natural capital and maximizing asset utilization. Sometimes, short-term actions evolve into long-term community-empowering interventions. For example, StadtAcker in Munich was initially promoted and kept alive among the population through decentralized, small scale, mobile gardening events in the neighbourhood contributing to building the gardening community. Citizens are generally engaged in increasing awareness. A few of them engage members to solve problems (see, for example, Ugly Indians). Observed obstacles are both, internal and external, mainly related to the financial sustainability of regularly performed actions and support of the local government. Despite its temporary nature, this type shows beneficial impacts on the environment and society and influence on city planning. This SI type was called *strategic citizens*.

4.3. Commonly organized consumption

This type of initiative focuses on interventions in which consumption communities replace current consumption practices with the sharing and exchanging of goods to maximize assets utilization. Non-profit organizations provide them with facilitation structures (sharing services, virtual platforms and networks) in the product, built environment and mobility systems to engage people in collaborative consumption practices. These interventions are mainly focused on consumption practices: citizens are engaged to solve problems by sharing resources such as goods as well as information like needs, preferences, and ideas. They are motivated by the desire of saving money and space and decreasing their environmental impact. These initiatives are generally implemented in more locations within a city, connected through virtual platforms and supported by networks for community building. Fat Llama is an online platform that facilitates the peer-to-peer rent of privately own items. Lenders are covered by the platform through insurance (Arup and EMF, 2019). In the built environment, the “assets sharing model” encourages

the use of underutilized spaces for short-term peer-to-peer letting and renting. HomeShare International is a network specialised in facilitating intergenerational home-sharing by linking people in need of an affordable accommodation (mainly youngers), with those in need of support for living at home independently (usually elderlies) (Arup and EMF, 2019). It is a type of initiative that is well-consolidated: interventions are replicated nationally, internationally and also worldwide and linked in networks. For example, Smarta Kartan is an open-source smart-mapping tool developed by the City of Gothenburg with citizens to display where to rent, borrow, share, barter, and give things. It includes bicycles, kitchens, groups of exchange, swapping of clothes, free shops and more (Arup & EMF, 2019). Sharing Cities Network is a non-profit platform that links sharing initiatives in cities. It provides an online source to encourage sharing practices among local communities and a network to connect actions internationally by a hub (De Majo et al., 2015). In this SI type, obstacles are mainly due to the need for skills to build and run the initiative and the scarcity of funds and resources to develop the services (if the initiatives are not supported by the local authority). Benefits are identified in the environment because of the reduced use of resources and number of consumption-based emissions, in the economy because of money and space-saving, on society because of the inclusion of different stakeholders, and increased involvement and value for the local communities and finally in people behaviours because of more sustainable consumption practices. This SI type was called *sharing citizens*.

4.4. Competence-expanding prosumption and consumption

This type of initiatives focuses on enhancing competencies to support self-production and product-life extension. By providing facilities and supporting skills acquisition, it engages citizens in replacing current production and consumption behaviours in the product system with ecological design, self-production, and repair practices. It offers facilities in terms of material settings like labs, workshops and tools as well as in social settings like networks and platforms for knowledge exchange. Fab labs, hackerspaces and maker spaces aim to democratize production by personal fabrication, shared knowledge and technology, and local decentralized workshops. Repair cafés serve consumers who need to repair products in a free meeting place and ‘community-centred workshop’. People work with volunteer fixers on repairing broken or faulty products and maintaining them to prolong products life and reduce waste. Moreover, many Repair Cafés assist with product modification, particularly to clothing, to improve fit and appearance. We observed that the analyzed initiatives are mainly implemented in the product system and promoted by informal and no-profit organizations. There is an exception in the private sector: iFixit is an open-source website and worldwide repair community that supports people learning how to repair things. The wiki-based platform is renowned for open-source repair manuals and product teardowns, and it is combined with a sales platform for tools and spare parts. Consumers have the resources they need to fix their consumer electronics. Moreover, the website empowers individuals to share their technical knowledge with the rest of the world. Anyone can create a repair manual for a device and edit the existing set of manuals to improve them. This initiative has also built partnerships with manufacturers to promote repair. All the studied initiatives are well-established and replicated around the world. They focus on engaging and empowering people through skills building and knowledge sharing as well as problem-solving. Impacts are observed not only in the environmental and social areas but also in the economic area. These initiatives provide economic benefits (local economies and supply chains, skills, and job opportunities), environmental benefits (reduction of material consumption and waste) but also social benefits (civic engagement and social inclusion). Observed challenges are mainly internal. Money is frequently an issue. Income from membership and other services is not always guaranteed to cover costs. As such, many initiatives are reliant on external support, such as grant funding. The lack of strong roots locally and active involvement of diverse local stakeholders

(to build local sponsorships and authority support) as well as the need of being networked globally to facilitate knowledge exchanges are also seen as common challenges among these initiatives. This SI type was called *do-it-yourself citizens*.

4.5. Knowledge-expanding production

This type of initiatives refers to networks of citizens who collect and share data for producing knowledge to improve understanding of environmental and societal issues (Angelidou & Psaltoglou, 2017). This category involves initiatives such as citizen science and science shop projects promoted or led by citizens with the support of academic and research institutions. It also includes platforms for people-powered research such as Zooniverse in which volunteers around the world participate in crowdsourced scientific research by active involvement in research tasks (The Zooniverse, 2020). In these initiatives, citizens shape the direction of research towards challenges of their interest and contribute to knowledge that may be underappreciated by the scientific establishment. These initiatives enable citizens to learn about topics like air quality or mobility as well as increase awareness of problems and advocate for socio-political changes (Hecker et al., 2018). Data and outputs are freely accessible, and citizens collaborate in research by playing a crucial role in data gathering and sharing to address questions (Cooper et al., 2007). Thanks to the availability of affordable and user-friendly hardware (sensors and devices) and software, citizens are actively involved in data collection and sharing on challenges aimed at improving understanding and devising informed solutions to tackle them. Data are shared by platforms with a network of peers. In Zooniverse, volunteers help researchers in accessing and analyzing information quickly and accurately, saving time and resources, and leading to improved progress and understanding (Zooniverse, 2020). Initiatives have been implemented in different knowledge areas across the humanities and sciences such as air pollution, rainwater management, land use, mobility, and food security (EU-Citizen.Science, 2020). They are promoted by informal organizations in combination with public organizations (research centres or universities) that involve groups of citizens. These initiatives are focused on providing knowledge and evidence, but also can have a prominent effect on participants' behaviours and attitudes for sustainability transitions in areas such as renewable energy, public health, or environmental conservation (Sauer-mann et al., 2020). Challenges in their implementation are mainly identified in the increasing need for diversity, level and intensity of participation, the need of addressing the social-technical aspect of sustainability and tensions with the traditional academic science (Sauer-mann et al., 2020). The main outcome of these initiatives consists of knowledge development for improving understanding of environmental and social challenges, people engagement in evidence-led interventions on civic issues and policymaking. This SI type was called *sensor citizens*.

4.6. Resource-light/waste-avoiding production and consumption

These initiatives are mainly promoted by businesses and non-profit organizations that encourage new meaning and values in the product and food systems to improve the management of materials, waste and land. Citizens are involved in this type of intervention as consumers who respond to their needs by choosing a variety of products and services sometimes combined with platforms aiming at replacing established production and consumption practices with sustainable ones. Opendesk is a furniture platform that connects customers with designers and local makers/material suppliers. It aims to improve the supply chain efficiency by reducing intermediaries and length while increasing the designers and makers' profit and providing customers with access to high-quality, more affordable furniture (Arup and EMF, 2019). These initiatives encourage solutions for tackling environmental issues combined with social and economic problems. They provide innovative products and services based on CE strategies like regenerate natural capital,

optimize supply chains and implement reverse cycles to reduce raw materials usage and waste generation. BIG REuse is a non-profit organization that takes a multi-faceted approach to materials recovery and reuse. They run two warehouses selling a wide assortment of reclaimed materials, appliances, accessories and furnishings to the public at reasonable prices as well as support a local community-scale composting network. They provide training and fund local, environmental initiatives by their net revenue (Arup, 2018). People are mainly engaged in solving problems and providing information. Analysed initiatives are commonly affected by challenges like building sustainable business models, becoming profitable activities by social entrepreneurs and stable supply chain management, need for investment in capacity building and knowledge exchange, and access to support and infrastructures. We observed that initiatives based on public-private or no profit partnerships and supply chain networks have been able to establish sustainable business models. Halle 2 is a public-no profit partnership in Munich that offers a second-hand store for used products collected at the 12 recycling centres. Munich has one of the best waste management systems in Europe, and conscious that many things taken to their centres could be reused, the city set up Halle 2. It extends the lifetime of useful everyday items while offering unemployed people qualifications and job opportunities by providing a repair cafe, spaces for social events, and auctions of second-hand goods. It is also a learning space to improve the processes of collection, evaluation and selling of used goods. Edible Garden City is a no-profit enterprise that implements a sustainable closed-loop urban farming system and food supply chain in the city. This initiative relies on a combination of commercial activities, community farming, educational activities and social engagements. It has found support in the local government itself committed to the implementation of urban agriculture for improving city resilience and food security. Proven benefits are highlighted in the environment and society areas. They play a decisive role in encouraging more efficient use of resources while fostering job opportunities and increasing autonomy and self-reliance. This SI type was called *zero-waste citizens*.

4.7. Need/utility-oriented consumption

This type of initiatives focuses on need/utility-oriented consumption practices like letting and renting to satisfy user needs while dealing with the rise in costs for living. Citizens satisfy their needs and avoid inefficient arrangements such as ownership through services that allow them to let and rent products (Library of Things), spaces (shared office) and transportation modes (carsharing and bike renting). Initiatives are mainly promoted by non-profit and private organizations that provide innovative services and platforms for accessing spaces, products or transportation means without the need to buy them. They aim to

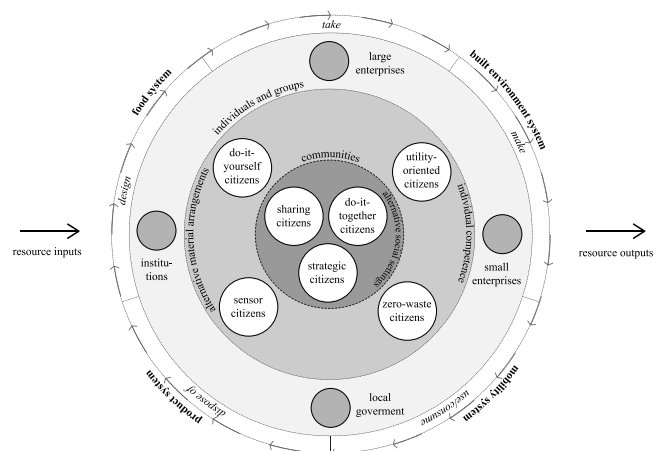


Fig. 5. SI for resource circularity in social housing communities.

Table 9

SI for a CE in social housing communities: opportunities, benefits and challenges.

Do-it-together citizens

Opportunities - this type shows residential-based and intentional groups involved in alternative prosumption practices in the built environment and food systems (housing, common spaces, urban and green areas) into their community. It includes a wide range of initiatives appropriate for social housing communities from interventions that promote self-build housing initiatives for those in housing need such as the unemployed, people on low incomes and the young (for example, self-build community) to interventions focused on alternative prosumption of specific resources (for example, food). In self-build community interventions, self-building provision needs to be embedded in the social housing strategies and liaised with training organizations to provide National Vocational Qualifications. This initiative helps those involved to gain skills and experience having secured jobs after completing homes. Housing tenure arrangements can vary according to circumstances, and the amount of self-building can also vary by project. Other suitable initiatives are the interventions focused on alternative prosumption of selected resources (see, Community Gardening, Community Growing, Community Buying, and Community Composting). For example, Stadtacker is an urban gardening community in a neighbourhood in Munich that manages a garden in the neighbourhood in which volunteers work together to maintain it.

Benefits - this type of SI can support social housing communities in promoting alternative prosumption practices while reducing waste, creating a more cohesive community, enhancing people's skills, and increasing community ownership by their involvement in decisions about housing and the neighbourhood.

Obstacles - challenges are mainly related to the needs for coordination as well as access to land, infrastructure and financial support from local authorities. Risk of failure during the development and costs of infrastructure represent the main obstacles for implementation (Alabare, 2020).

Strategic citizens

Opportunities - This type of SI can involve social housing communities in short-term initiatives through a series of temporary events for responding to community challenges such as the use of urban land for community purposes (such as gardens, allotments, and playgrounds).

Benefits - This type could be beneficial to social housing community in an early stage of the SI implementation process to build a group of interest, identify common issues relevant to the community, promote common knowledge, and increase awareness. A series of decentralized, short-term and small-scale events similar to the actions promoted by Park(ing) Day, as an example, can help in an early stage to lay the premises for the development of a long-term intervention.

Obstacles - Its implementation needs the support of a facilitator to encourage networking into the community and involve members in co-creation. Limits on its implementation are mainly due to the financial sustainability of actions in relation to the frequency.

Sharing citizens

Opportunities - This type of SI can engage social housing communities in maximizing the utilization of products, space, and transportation modes through sharing and exchanging. These alternative consumption practices are facilitated by services combined with virtual platforms. Social housing communities can consider joining existing networks and virtual platforms that maximize products utilization by peer-to-peer renting like Fat Llama or through giving or getting goods for free such as Freecycle or Freegle. Social housing communities can also reflect on the possibility to offer short-term accommodation through sharing services like HomeShare International and FairBnB. FairBnB is an accommodation booking platform that allows locals to offer rooms, full apartments and houses. The platform charges a booking fee on the traveller which half is retained by the service for its operations, while the other half is used to crowdfund local community projects. Finally, new opportunities are emerging through carsharing. Residential based communities can incorporate new residential, private-access shared-car models to replace private automobiles, reduce demand for parking spaces and add value to members.

Benefits - Besides the impact on the community environment, thanks to the reduction of waste and resource use by more sustainable consumption practices, benefits for the community can be identified in money and space-saving, as well as in increased community involvement and value.

Obstacles - Challenges for social housing can be identified in the case a community intends to join existing sharing services as a provider due to the need for building credibility and trust, contractual obligations with the housing associations, and availability of appropriate insurance policies.

Do-it-yourself citizens

Opportunities - This type of SI can involve social housing communities in building individual competencies by the support of existing facilities and networks (for example, FabLabs and Repair Café). These interventions provide facilities and support to acquire capabilities for encouraging self-production, maintenance, repairing and reusing of products. While these facilities can contribute to addressing the community's needs and having a real impact on communities, social housing communities can help them in establishing strong roots locally. For example, it is acknowledged that FabLabs have difficulties in finding ways of being locally relevant and attracting a diverse range of stakeholders. They depend financially on public funding and have financial difficulty in the absence of that while they lack stable connections with the local ecosystem to generate revenue. Social housing communities can help them in building strong relationships locally. On the other hand, Fablabs can support social housing communities to develop capabilities, help the unemployed, create entrepreneurs, promote inter-generational and sharing learning, minimize resource use and promote local production. Repair Cafe' is another initiative suitable for social housing communities to support the repairing of broken or faulty products as well as provide assistance with product modification and maintenance.

Benefits - they can be beneficial in terms of valuable practical knowledge acquired by participants, reduction of waste in the community from products as well as money-saving.

Obstacles - since these initiatives require capacity and skills building, access to support and infrastructure, they are not suitable for implementation by social housing communities. Successful examples such as Halle 2 show the involvement of repair cafes in a larger partnership with no-profit organizations and the local government to implement a sustainable business model by resource circularity, stable supply chains and upstream infrastructures. However social housing communities can be key stakeholders for their flourishing and establish a stable relationship for mutual benefits.

Sensor citizens

Opportunities - This type of SI can involve social housing community in initiatives such as Citizen Science and Science Shop projects in which participants contribute to project development by collecting and sharing data to improve understanding about topics of their interest such as air quality or mobility as well as increase awareness and advocate for sustainability changes.

Benefits - These initiatives can help in building interest in these topics, increasing awareness and influencing people's behaviour into the community, as well as create the premises for the implementation of future initiatives focused on problem-solving. Also, they can influence participants' behaviours and attitudes toward sustainability transitions.

Obstacles - Challenges in social housing communities for the implementation of this type of SI result mainly related to the diversity, level, and intensity of participation.

Zero-waste citizens

Opportunities - This type of SI can engage social housing communities mainly as consumers and supporters. It brings producers closed to consumers by building a social cooperative relationship. Thanks to this relationship, consumers appreciate and support resource-light and waste-avoiding production practices of food and products. These initiatives play a crucial role in connecting people and creating more cohesive communities by the promotion of group and individual capabilities and access to resources and facilities. For example, Growing Communities is a not-for-profit company that uses the collective buying power of its community to create a market for sustainable food producers. They have created community-led trading outlets and urban food growing sites that provide training for apprentice growers and volunteers. CropDrop is a delivery service linked to Growing Communities and placed in the same community. It supplies food from local farmers (Growing Communities included). Crop Drop is run by residents and deliver the service in that community only to keep it local, sustainably grown, seasonal, fairly traded, low carbon and healthy. Growing Communities and CropDrop have built a community around sustainable food by involving local people in sustainable agriculture and urban growing events and training. Alternatively, communities can bring together independent producers, retailer and distributors to create virtual hubs and markets by platforms (such as Open Food Network).

Benefits - These initiatives play a decisive role in reducing waste and resource use by promoting more sustainable production and consumption practices of food and products while increasing community cohesion and self-reliance.

Obstacles - The subscription to these initiatives from the social housing community as a consumer and supporter does not show specific challenges.

Utility-oriented citizens

Opportunities - This type of SI can involve social housing communities in opportunities to satisfy their needs for products, spaces and transportation modes without owning them by letting and renting facilities combined with platforms. Social housing communities can consider linking existing facilities such as a Library of Things and contribute to their flourishing. This facility is generally implemented locally in a neighbourhood or more locations within a city. It is responsible for sourcing, maintaining and repairing 'things' in the library, as well as supporting the online platform and related digital services.

Benefits - Communities can benefit from the reduction of waste and resource use as well as from profit and money-saving for users. and

Obstacles - While the subscription initiatives from the social housing as a consumer and supporter does not show specific challenges, the implementation of a facility like a Library of Things into a social housing community can be challenging since it requires building capabilities, the acquisition of funding for the development of the facility, the access to infrastructures (such as spaces) and support as well as the development of a sustainable business model.

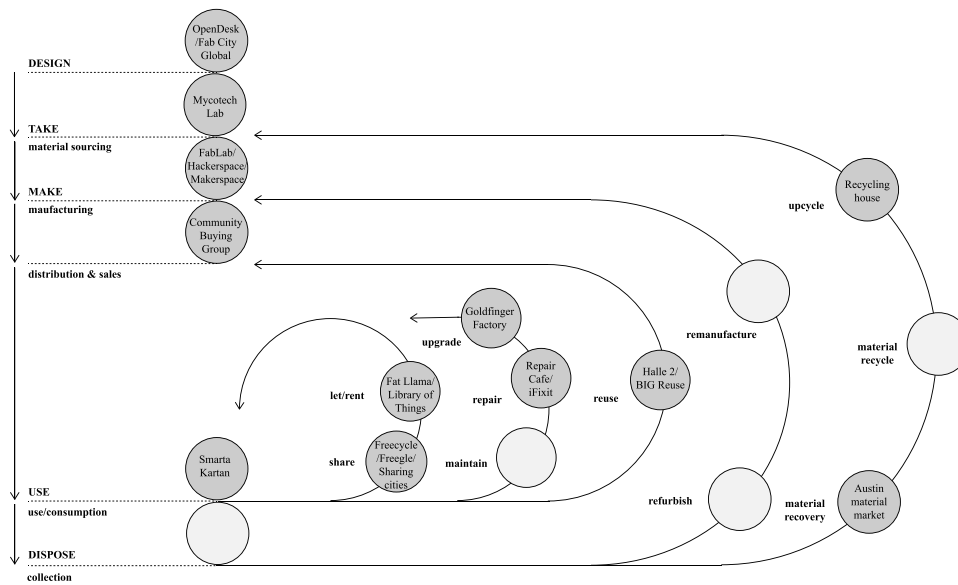


Fig. 6. SIs for a circular product system.

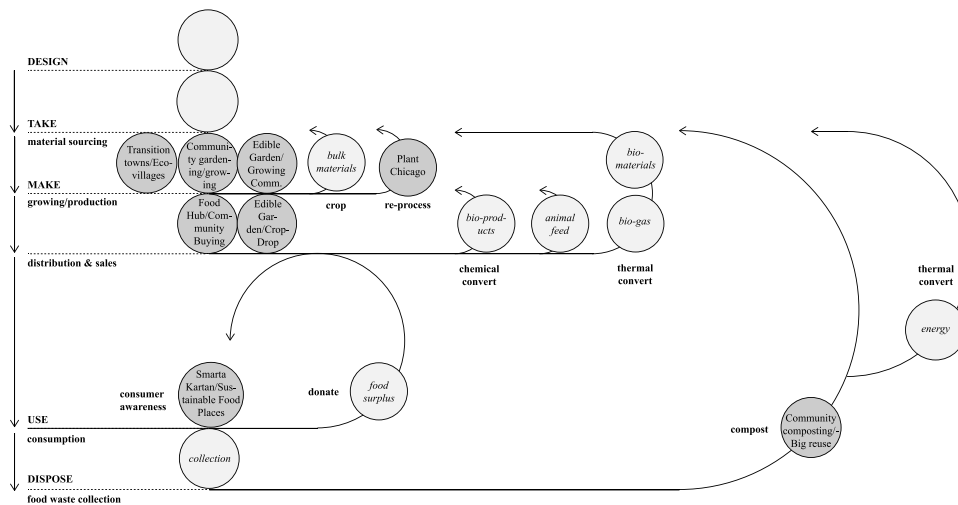


Fig. 7. SIs for a circular food system.

increase the utility value to satisfy user needs by adopting new business models based on letting and renting and enabled by digital platforms (Arup & EMF, 2020). The Library of Things is an organization that loans out kitchen appliances, gardening tools, electronics, and recreational equipment to its members in a procedure similar to conventional libraries. The organization is responsible for sourcing, maintaining and repairing 'things' in the library, as well as supporting the online platform and related digital services (Library of Things, 2020). In the built environment, this SI type promotes the use of spaces for short-term or long-term letting and renting (such as office spaces). New business models that involve building assets are just starting to be explored. Their implementation requires an understanding of the relationships among technologies, ecosystems, social and cultural practices as well as city governance and their effect on design decisions (Arup & EMF, 2020). The initiatives highlighted above have faced internal and external challenges such as credibility, people's lack of trust as well as the availability of appropriate insurance policies for new business models. Impacts are mainly identified in the environmental area because of the reduction of raw material demand and waste generation as well as the economic area because of money-saving/profit for users. This SI type was called *utility-oriented citizens*.

Based on these results, the study defined the potential contribution of

social housing communities to the transition to a CE in cities and provided insights for knowledge contribution to the CE approach.

5. Discussion

5.1. The potential contribution of social housing communities to the transition to a CE in cities

Based on the developed database and typology, we explored opportunities, challenges and benefits for social housing in cities to develop SI initiatives for resource circularity in their communities.

Social housing constitutes residentially based communities with full potential for achieving social cohesion. This type of settlement allows people to build social relations, share challenges, values and goals and develop communities of place and interest. According to current knowledge on behavioural change, people acting in groups of interest and communities have a decisive role in breaking habits and devising new attitudes and values on citizens because of their capability to provide social support and feedback (Jackson, 2005). Through SI initiatives, people are encouraged to change social practices and enhance their capacity to act by new relationships, assets and capabilities as well as improved access to power and resource use (The Young Foundation,

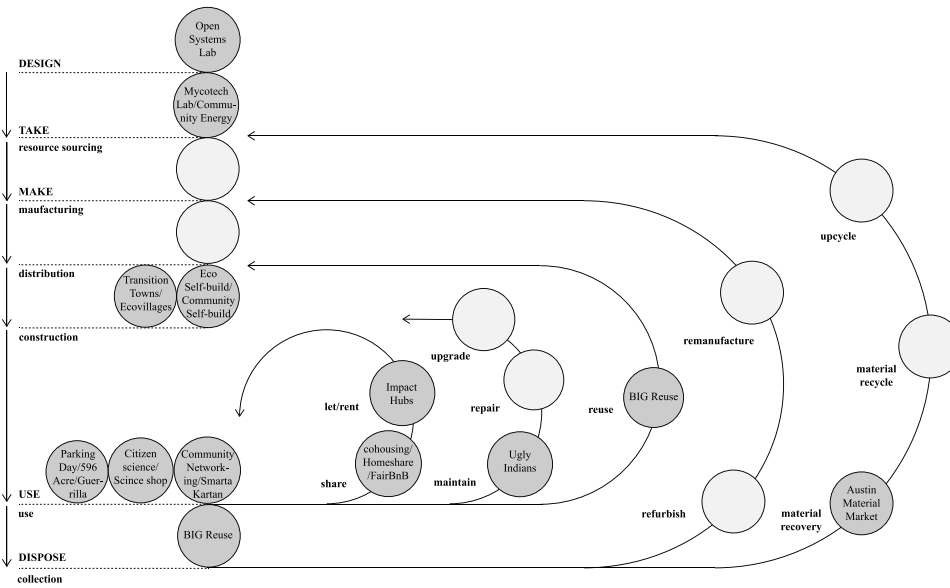


Fig. 8. SIs for a circular built environment system.

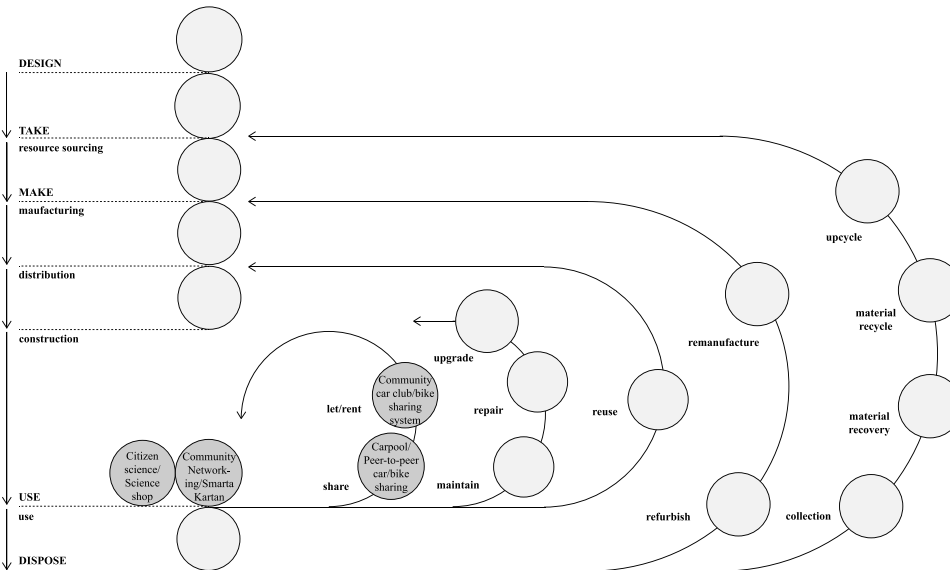


Fig. 9. SIs for a circular mobility system.

2012). The developed case study analysis and typology show that communities play a motivating role by stimulating cooperative social relationships for circularity and resource efficiency through several types of SI initiatives from community growing to social enterprises. Communities are key players in the implementation of collaborative interventions for the improvement of resource management into the community. Community-based initiatives constitute a consistent part of the analysed phenomenon. In these initiatives, members are involved in a group in a process of interaction, responsibility, and mutual influence. Communities are also key stakeholders in the implementation of SI interventions promoted by groups of citizens for the improvement of resource management into the city. In these initiatives, community-building results in being a crucial aspect to encourage alternative supply chains that bring producers closer to consumers establishing mutual support. Based on the developed database, typology and literature review's findings, we defined the potential contribution of social housing communities in a CE through SI (Fig. 5) as well as opportunities, benefits and obstacles reported in Table 9. Findings show that SI initiatives in the category of alternative social settings can be

appropriate for social housing groups to promote alternative prosumption-consumption practices into their communities to reduce waste, save money, create a more cohesive community, enhance people's skills, and increase community ownership. The other SIs can involve social housing communities as key stakeholders to support alternative production-consumption practices into the city while connecting people, building more cohesive communities, creating a local economy and job opportunities by the promotion of new capabilities and access to resources and facilities.

These findings show that the emerging Housing Associations' interest to engage their housing communities in a transition to a CE can bring opportunities and benefits to their communities as well as entail challenges. This emerging aspiration can be addressed by the implementation of interventions selected by the community with the support of the Housing Associations according to people's interests, challenges of the community, expected benefits, available infrastructures and support, existing facilities and networks, and required skills and capabilities.

Table 10

The ReSOLVE framework for SI – SI-CE actions and SI opportunities for a CE.

SI action	CE actions	SI opportunities for a CE in urban systems
engage and empower <ul style="list-style-type: none"> providing information and resources, identifying problems, underlying issues and solving them collectively taking collective decisions which influence community policymaking and local government 	regenerate	<i>regenerate natural capital</i> <ul style="list-style-type: none"> preserve ecosystems and improving resilience by community initiatives like community gardening, community growing, land reclaim actions/events, and urban farming enterprises return recovered biological resources safely to the biosphere by community composting, and community-scale composting network (e.g., BIG Reuse)
	share	<i>maximize assets utilization</i> <ul style="list-style-type: none"> share building assets and spaces (home, office, common spaces) by community initiatives like co-housing and community hub or by facilities (e.g., HomeShare, FairBnB, Impact Hubs) share products (items, appliances and devices) by facilities like carpooling, peer-to-peer car/bike sharing and by digital platforms (e.g., Fat Llama and Smart Kartan) share information by science shop and citizen science initiatives and by networks prolong asset use periods of goods and spaces through maintenance, upgradeability, etc. by facilities like hackerspaces, maker spaces, fab labs and repair cafes or by community actions (e.g., The Ugly Indian) or by community networks (e.g., Freecycle, Freegle)
	optimize	<i>optimize system performance</i> <ul style="list-style-type: none"> remove waste in production and supply chain of goods, foods and buildings by self-production initiatives like self-build communities, virtual platforms for self-production (e.g., Open System, and Open Desk), workshops (e.g., fab labs; hackerspaces, and maker spaces) or by local-distribution enterprises (such as CropDrop) or by collective purchases through community buying groups optimize the logistics system through the implementation of reverse logistics by networks (e.g., Edible Garden City or The Plant Chicago)
	loop	<i>keep assets in closed loops and priorities inner loops</i> <ul style="list-style-type: none"> repair products by repair cafes and virtual repairing community platforms (e.g., iFix) reuse products (furniture, goods, appliances, vehicles) by reuse centres/enterprises (e.g., BIG Reuse, and Halle 2) refurbish/remanufacture products (no cases in the case study selection) upcycle products by no-profit organizations (e.g., Goldfinger Factory and Recycling House) recover materials and bio-products by finding reuse and recycling solutions through an online platform (e.g., Austin Material Market) digest anaerobically such as closed-loop zero-waste food production (e.g., The Plant Chicago) extract biomaterials/products from organic waste (e.g., Mycotech Lab)
	virtualize	<i>dematerialize resource use</i> <ul style="list-style-type: none"> access to bio-products and materials as well as reuse and recycling opportunities by online market platforms (e.g., Austin Market Place) access to resources use (materials, goods, spaces, vehicles) by online platforms (e.g., Fat Llama, FairBnB, and Carsharing) access to knowledge by online platforms (e.g., Citizen Science and Science Shops) support networking virtually by online platforms (e.g., Transition Network, Global Ecovillages Network, Just Space, Sharing Cities; and Fab City Global) support land access advocacy by online maps (e.g., 596 Acres) provide information by digital support (e.g., Smarta Kartan) optimize value chains by online platforms (e.g., Open System; and Open Desk)
	exchange	<i>select resources and technologies knowingly</i> <ul style="list-style-type: none"> move to renewable energy and renewable material sources (e.g., Community Energy for renewable electricity, and Mycotech Lab for agroforestry by-product); substitute traditional technologies with advanced ones (e.g., Edible Garden City for aquaponics) substitute models focused on ownership with models focused on renting or letting (e.g., Library of Things for products, Impact Hubs for office space, community bike and carsharing for mobility)

5.2. Knowledge contribution to the CE

The developed database offered a framework to understand opportunities, challenges and benefits from SI for resource circularity in cities. It also provided insights for knowledge contribution to the CE.

SI shows to stimulate the creation of communities, networks of people, businesses and social enterprises that promote alternative production-consumption practices in urban systems. Based on the database, the diagrams below display CE opportunities implemented by the case studies in the product system (Fig. 6), food system (Fig. 7), building system (Fig. 8) and mobility system (Fig. 9). These diagrams provide an overview of the potential role that SI can play in the transition to the CE in urban communities and groups of interest. It emerges that SI can contribute to a CE through citizens engagement in alternative practices in cities, but it needs to be integrated with wider collaborations to foster resource circularity.

Since existing approaches to a CE are technology-business oriented and they currently do not include SI, this study formulated theoretical insights and proposed to integrate SI aspects into an existing CE approach for supporting the implementation of opportunities.

Specifically, using the case studies analysis, we observed that the ReSOLVE framework does not include at all SI concepts. How people are involved in developing and sustaining new practices, as well as the intrinsic people's motivation that stimulates engagement in an activity, have shown being crucial for the SI implementation and growth. Therefore, the framework was extended by the introduction of the strategy “engage and empower” to combine with CE actions for promoting the implementation of SI initiatives for a CE. Then, SI initiatives were listed according to each CE action. Table 10 shows SI-CE actions and related potential SI initiatives.

Findings provide insights about potential benefits achievable by SI for resource circularity in urban communities and group of interest as well as the main challenges to take into account (Table 11).

6. Conclusions

The study investigated the potential contribution of social housing communities to the transition to a CE in cities. The CE is an alternative to the traditional linear approach aimed at improving resource efficiency to allow cities to prosper sustainably. Until now, the CE has mainly

Table 11

SI for a CE: potential benefits and challenges.

Potential benefits
<p>The main benefits observed across initiatives based on potentials and empirical evidence are:</p> <ul style="list-style-type: none"> - environmental - reduced use of raw materials and energy as well as reduced consumption-based emissions and waste), - economic - (money and space-saving, local economy and supply chains development, job opportunities creation), - societal - (capabilities building, increased community cohesion, and civic engagement) - behavioural - attitude towards sustainability transitions
Challenges
<p>The main challenges observed across initiatives that affect growth are:</p> <ul style="list-style-type: none"> - internal factors - 1. the need for human capacity and skills; 2. the lack of local networks for resource circularity; 3. the lack of understanding of real impacts; and 4. the lack of sustainable business models; - external factors - 5. the shortage of economic support; 6. the lack of access to information and infrastructures, and the scarcity of support from decision-makers. <p>1. <i>building human capacity and skills</i> - the growth of initiatives requires investment in capacity building by training programmes and knowledge exchange such as farmer-to-farmer and trader-to-trader learning. It requires the creation of trans-local networks for exchanging good practice, building local resource flows and complementary systems.</p> <p>2. <i>local networks for resource circularity</i> - in general, the studied initiatives are connected with counterparts to create networks for sharing information and overcoming the local dimensions at the regional, national or international levels, but they lack the creation of local networks with other stakeholders to generate local resource circulation in complementary ecosystems and relationships with local communities to guarantee their growth. There are a few exceptions in zero-waste initiatives such as Edible Garden City, The Plant-Chicago and Community Growing combined with CropDrop involved in supply chains for closed resource loops.</p> <p>3. <i>understanding of real impacts</i> - At the project level, most of the initiatives lack understanding of their real impacts by adopting appropriate impact metrics and assessment. Addressing this aspect is essential to attract cross-sectoral support, establish collaborations and partnerships as well as find and optimize SI positioning among wider society.</p> <p>4-5. <i>sustainable business models and economic support</i> - Most initiatives depend on external/public funds and volunteers' work to run and lack sustainable business models. The future of these initiatives depends on their ability to generate revenue, create a micro-economy and become economically sustainable. Initiatives that have integrated different business models and built partnerships show the capability to create micro-economy and sustainable financial models. For example, Halle 2 and Edible Garden rely on holistic approaches that combine different models to pursue a long-term vision of sustainability: commercial activities, community activities, educational content and societal engagements.</p> <p>6. <i>access to infrastructures and support from decision-makers</i> - As an example, the diffusion of SI interventions in the food system requires access to secure, affordable land and infrastructure as well as transformations in policy and planning to value and invest in these types of practice. The support of local government through the creation of a public-private partnership helps initiatives link multiple actors and agencies and deal with main challenges like land access. Government involvement is also crucial for increasing awareness among citizens.</p>

focused on technological innovations at different levels with limited emphasis on social practices and user behaviour changes. However, resource efficiency depends on consumption and production patterns that are related to changes in the behaviour of people. The implementation of a CE in social housing has mainly focused on developing flexible and adaptable housing technological assets, while the role of social housing communities in the transition to a CE has not yet been explored. Similar to residentially based communities, people in social housing tend to constitute networks with shared values and sense of membership. The role of groups of interest and communities is crucial in promoting behavioural changes since people are more willing to change and stabilize changed practices when they are engaged in collective initiatives with peers (such as their neighbours) called SIs. Despite the crucial role of these initiatives, they are little investigated. Since they can promote changes in production-consumption practices through citizens' engagement in urban communities and groups of interest, the study focused on understanding the phenomenon of SI for resource efficiency in cities through case study analysis and comparison. These activities provided the identification of seven types of SI for a CE in urban communities and groups of interest. Based on the developed database and typology, we showed that the emerging Housing Associations' interest to engage their housing communities in a transition to a CE can bring opportunities and benefits to their communities as well as entail challenges. Specifically, SI initiatives in the category of alternative social settings can be implemented by social housing groups into their communities to promote alternative production-consumption practices for reducing waste, saving money, creating a more cohesive community, enhancing people's skills, and increasing community ownership. The other SIs can involve social housing communities as key stakeholders to support alternative production-consumption practices in the cities while connecting people, creating a local economy and job opportunities by the promotion of new capabilities as well as access to resources and facilities. Moreover, the developed database offered a framework to understand the contribution of SI for resource circularity in cities. The findings showed that SI can promote CE practices in communities and groups of interest, and it can hold a complementary role with the industry, government and institution in the implementation of a CE. We

observed common challenges and obstacles that affect SI initiatives and limit their growth: the dependence on external/public source funds or volunteers' work; the lack of sustainable business models; the need of building human capacity and skills; difficulties in scaling up because of lack of access to infrastructures, economic support and support from decision-makers; the low understanding of their real impacts limiting cross-sectoral support and collaborations across wider society. They show to overcome strong barriers and prosper sustainably when they are paired with "upstream" interventions and involved in local networks for resource circularity with other key stakeholders. Therefore, since existing approaches to a CE do not include SI, the project suggested the introduction of emerging SI concepts to foster the development of SI opportunities for a CE. Specifically, we proposed to add the strategy "engage and empower" to the ReSOLVE framework and combine it with CE actions to identify opportunities.

In the following research stage, the study will validate findings identified in this study through the involvement of a social housing community by gamification in the collaborative discovery of different possible scenarios for the transition to a circular community and bottom-up knowledge.

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Declaration of Competing Interest

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